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FISHERIES ECOLOGY ABSTRACTS

TOWARDS AN UNDERSTANDING OF DOLPHINFISH ABUNDANCE: AN INTERPRETATION OF THE RELATIONSHIPS BETWEEN ENVIRONMENTAL VARIABLES AND SPECIES ASSOCIATIONS FROM THE U.S. PELAGIC LONGLINE FLEET

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Understanding the fluctuations in marine fish stocks is important for the management of fisheries, and attempts were made to demonstrate links with oceanographic and climatic variability. The pelagic longline observer program is a useful tool for studying correlations between environmental and vessel parameters and the various species caught by the longline fleet because of its high spatial resolution, which allows a linkage between the catch data and environmental parameters. We modeled catch-per-unit-effort (CPUE) of dolphinfish (*Coryphaena hippurus*) with several other species that are frequently caught by the United States Pelagic longline fleet in a Principle Components Analysis (PCA) in two distinct biogeographic areas: the Gulf of Mexico and the east coast of the United States. The catch PCA demonstrated that the species were not strongly intercorrelated and therefore dolphinfish were analyzed individually with the environmental parameters. PCAs are presented for dolphinfish individually against oceanic conditions and effort characteristics both for the total datasets and by season for the east and west. In all cases, over 70% of the variability in the data was explained by the first three components. Results suggest that dolphinfish are positively correlated with SST and negatively correlated with proximity of a front, and that the PCAs provide a picture of the areas in each region that are important for higher CPUEs of dolphinfish.

DISTRIBUTION AND ABUNDANCE OF LARVAL TUNAS (SCOMBRIDAE) ASSOCIATED WITH THE LOOP CURRENT, PELAGIC *SARGASSUM*, AND OCEANIC FRONTAL ZONES IN THE GULF OF MEXICO

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Information is lacking on the distribution and abundance of tuna larvae in relation to their seasonal occurrence at oceanic pelagic habitats in the northern Gulf of Mexico. Atlantic bluefin (*Thunnus thynnus*), yellowfin (*Thunnus albacares*), blackfin (*Thunnus atlanticus*), and unidentified tuna larvae (*Thunnus* spp.) were collected during a 2000–2003 investigation of larval and juvenile fishes associated with pelagic *Sargassum* and oceanic frontal zones in the northern Gulf of Mexico, as well as with the Loop Current. Tuna larvae (n = 380) occurred in 49% (n = 77) of the collections taken during the study (n = 158). Larvae were collected from surface and subsurface waters by neuston net (505µm), bongo net (333µm), and Tucker trawl (333µm). Sampling occurred only during day time, and tuna larvae were not collected shoreward of the 300m isobath. Mean abundance of bluefin larvae (3.4 – 8.6 mm; n = 124) was highest in collections from the Loop Current boundary and were collected only in May, providing further documentation of a compressed spring spawning season for this species in the Gulf of Mexico. Larvae of yellowfin (3.7 – 7.9 mm; n = 18) and blackfin tuna (3.6 – 7.3 mm; n = 47) were present in northern Gulf collections at *Sargassum* and frontal zones (none from the Loop Current) from May through August of all years, indicating a protracted spawning season in the region for these species. No tuna larvae were collected in fall and winter. Unidentified larvae (*Thunnus* spp.) require further examination for purposes of species identification. Continued research is critical to advance the scientific understanding of the biology, ecology, and habitat requirements of young tunas in the northern Gulf of Mexico.

ADVANCES IN THE STUDY OF BILLFISH EARLY LIFE HISTORY

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Recruitment dynamics of marine fishes are largely driven by processes operating during the early life history (ELH) stages. Yet, for billfishes, the early stages have been only cursorily studied, in part due to the large spatial extent of potential larval and juvenile habitat, difficulties in collecting sufficient numbers of young, and adequately resolving the taxonomic identity of specimens. Early work solved some of the identification issues based on morphological characters, at least for the Pacific, but sufficient resolution was still hampered. Nonetheless, opportunistic sampling, and some targeted efforts, have helped identify potential areas where spawning may be occurring, and provided some idea of the temporal pattern of spawning activity. With the onset of more definitive molecular identification techniques, and advanced sampling systems, more extensive studies into the dynamics of the ELH of billfish are now possible. Here I discuss one such program that was developed to address several aspects of the ELH of billfish within the Western Central Atlantic, with a focus on the Straits of Florida (SOF). Specifically, this study is directed at providing a seasonally-resolved understanding of billfish spawning, larval growth, feeding, and transport within the oceanographic context of the SOF. The work includes measures of the temporal qualities of cross-strait features (i.e., water mass distribution, larval billfish patches, and zooplankton community structure) via monthly sampling (ichthyoplankton, zooplankton, CTD, fluorometry, and ADCP measurements) linked, via otolith aging studies and circulation patterns, to estimates of spawning locations. Otolith work on larval growth rates will be coupled to zooplankton work on community composition and dynamics to identify trophodynamic differences among patches. Ultimately, information on the flux of larvae through this system combined with knowledge of the reproductive output of billfish, may provide estimates of spawning production, and hence, stock size within this region.

DENSITY AND BIOMASS VARIATION OF MICRONEKTON CLOSE TO FISH AGGREGATING DEVICES (FADS) AROUND MARTINIQUE

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The numerical and ponderal variations of micronekton around fish aggregating devices (FADs) have been studied in Martinique using day/night sampling from upper 200 m depth with a mesopelagic trawl. The trawl used is an Isaac Kidd-like type, of 7,13 m² surface to the opening and a grid of four mm at the bottom. Forty six samples have been collected between July 2003 and April 2004. A total of 189 taxons of fish, squids and crustaceans covering 86 families were collected. In this article the micronekton's density and biomass variations are described using four parameters: the season, the day/night comparison, the depth and the distance to shoreline. The most abundant taxa composition in the samples is described in order to understand what participation they have in the diet of tuna.

FISH AND INVERTEBRATE IDENTIFIED DURING THE LESSER ANTILLES PELAGIC ECOSYSTEM PROJECT (LAPE), 26 APRIL TO 9 MAY 2006

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During the LAPE ecosystem survey, forage fish distribution and abundance have been estimated by acoustics. At points selected from acoustic traces, net sampling, with pelagic trawl or multi-net nekton sampler, has been used to obtain biological specimens of the acoustic target. The samples captured during the survey are introduced with

pictures and the most importants identification criteria used. The discribed micronekton is essentially composed of fishes, cephalopods, gastropods and crustaceans. This set of sheets is proposed as a reference collection to help in pelagic top predators stomachs contents identification in the Lesser Antilles.

ACOUSTIC BIOMASS ESTIMATES OF PELAGIC FORAGE SPECIES IN THE OFFSHORE WATERS OF THE LESSER ANTILLES

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A recently completed survey of the Lesser Antilles pelagic ecosystem used a combination of multi-frequency acoustics and pelagic trawling to locate and estimate the biomass of forage species. Stratified zig-zag transects covered the waters east and west of the Lesser Antilles from Antigua to Trinidad. Distinct pelagic layers and aggregations observed acoustically were sampled using a multiple (3) codend pelagic trawl. Pelagic organisms were identified to the lowest taxon possible and categorized by presence or absence of a swim bladder. The acoustic data were grouped into nine broad categories based on the multi-frequency returns considering backscattering strength, aggregation appearance, depth and time of day, The resulting acoustic density was converted to indicative biomass density (kg/m^2) by application of target strength estimates from published sources. Relative abundance and composition of the nine acoustically classified groups are presented.

SPATIAL AND DIEL DISTRIBUTION OF PELAGIC FORAGE SPECIES THROUGHOUT THE LESSER ANTILLES FROM AN ACOUSTIC AND MID-WATER TRAWL SURVEY

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COMPOSITION, DIVERSITY, AND RELATIVE ABUNDANCE OF OCEANIC SHARKS IN THE CARIBBEAN SEA AND ADJACENT WATERS

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The information analyzed was obtained by scientific observers on board the Venezuelan pelagic longline fleet targeting swordfish and tuna during 1994–2003. The total shark bycatch comprises a total of 25 species, in which the most frequently caught were *P. glauca* (34.76%) and *C. signatus* (20.15%). Other common species in the catch composition were *C. falciformis* (8.46%), *S. mokarran* (6.81%), and *I. oxyrinchus* (6.23%). Shark diversity analysis showed a decreasing trend throughout the time series. Areas with relative high diversity values were located in the southeastern Caribbean Sea, primarily in areas close to the islands and coasts of Venezuela. Other areas with significant diversity values corresponded to the inner arc of the Lesser Antilles and Suriname shelf. Annual CPUE trends for the five most important shark species revealed a declining in abundance during the time series. Shark catches for the most important species comprised a large proportion of juveniles. Major efforts, with support from the international community will be needed to generate the information required for the stock assessment of pelagic and coastal sharks in the Caribbean Sea.

ASPECTS OF THE BIOLOGY OF SHARKS IN THE FISHERY OF THE YUCATAN PLATFORM

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Shark capture in the state of Yucatan has increased from 450 ton in 1975 to 1,300 in 1994, thus occupying 4th place by its economic value and 7th place in importance considering its capture volume at the national level. Although the biological and fishing knowledge of this resource is essential to establish the rules for its management, little is known about the abundance and spatial-temporal distribution pattern of the species. The objective of the present study was to contribute to the knowledge of the population structure of the shark resource in Yucatan platform. The information gathered from 1985 to 1991 comes from ship records (knowledge of fishing area, depth, composition and weight of the capture, meristic data) and fishing landings (biological data). For the analysis of the community structure by zones and depth, a binary matrix of data was built (presence/absence) and multivariate analyses were carried out. The capture is composed of 27 species within 9 families. Dominant species, considering Sanders Index, were *Carcharhinus falciformis, Rhizoprionodon terranovae, Mustelus norrisi* and *Sphyrna tiburo* as well as *Hexanchus vitulus,* a species that was not reported before for the area. Five fishing areas were identified, and the east of the state was the one with the most fishing pressure. Most shark species showed a seasonal pattern, being captured most frequently during summer and autumn. In capture terms, the genus *Carcharhinus* supported the shark fishery with almost 50% of the records. Diverse association levels were obtained between species and areas. In relation to administration, the information doesn't allow formulation of regulations. However, already some preliminary recommendations have been considered, with a suggestion to not increase the fishing permissions for shark capture. It is concluded that some shark species in the Yucatan coast have suitable areas for living and breeding, but they have been subjected to heavy fishing efforts that could generate in the near future the collapse of this resource.

BIOLOGICAL STUDIES OF THE WHALE SHARK AGGREGATION OFF ISLA HOLBOX AND ISLA CONTOY, WHERE THE GULF OF MEXICO MEETS THE CARIBBEAN SEA

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Between mid-April and September each year, large numbers of whale sharks (*Rhincodon typus*) visit continental shelf waters off Mexico's Isla Holbox and Isla Contoy where the northwestern Caribbean Sea meets the southeastern Gulf of Mexico. Biological studies of these huge, pelagic planktivores to document their distribution, number, size, sex, behavior and migration began off Quintana Roo in August 2003, and have continued through 2006. Research methods comprise a combination of on-water and aerial surveys, tagging and tracking with visual and satellite tags, and logbook data collection by local guides and fishermen. Genetic tissue samples also have been collected for collaborating institutions. All data indicate at least several hundred whale sharks visit the area every summer to feed on plankton associated with a seasonal upwelling. Approximately 400 individual sharks have been tagged primarily in the summers of 2004–2006. Estimated size of observed sharks ranges 2–13 m TL; tagged animals range 3–12 m TL, with an average size of 6.7 m TL. Sex ratio is approximately one female for every 2–3 males. Mature and immature animals of both sexes are present. Resightings of tagged animals have been reported over 300 nm away from the tagging site and in subsequent years back at the site. Pop-off (PAT) satellite-tagging has confirmed migrations of nearly 900 km in one month and dives to at least 980 m when the sharks move off the Campeche Bank. Based on the number of animals documented to date, this area where the Gulf of Mexico meets the Caribbean Sea appears to be one of the world's most important population centers for the whale shark.

MERCURY CONTENT OF LARGE PELAGIC FISHES FROM THE NORTHERN GULF OF MEXICO

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The waters of the northern Gulf of Mexico (nGOM) support valuable recreational fisheries with many species retained for consumption. Evidence of the link between fish consumption and elevated levels of mercury in human tissue continues to accumulate. An investigation of total mercury levels in large pelagic fishes from the nGOM was initiated in the summer of 2006. Blue marlin (*Makaira nigricans*), yellowfin tuna (*Thunnus albacares*), wahoo (*Acanthocybium solandri*) and dolphin (*Coryphaena hippurus*) were sampled at Mississippi docks during fishing tournaments. Fish tissue sampling protocols and analytical techniques (direct mercury analysis) followed those used in a synoptic survey of total mercury in recreational finfish conducted by the National Seafood Inspection Laboratory, NOAA Office of Sustainable Fisheries. There were significant positive relationships between size and mercury concentrations in yellow and blackfin tunas, wahoo, dolphin, little tunny, and king mackerel. Highest individual value for total mercury was found in blue marlin (9.630 ppm) with an mean ($n = 6$) concentration of 7.099 ppm.

POPULATION STRUCTURE AND MOVEMENTS ABSTRACTS

BLUE TRAVELERS: IS THE SUSTAINABILITY OF ATLANTIC BLUEFIN TUNA AND BLUE MARLIN STOCKS LINKED TO THE GULF OF MEXICO?

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Atlantic bluefin tuna and blue marlin are highly migratory species that commonly cross ocean basins or political boundaries, and thus the fate of each species in influenced by activities (i.e. fishing) throughout their home range. Here, we examine the role of the Gulf of Mexico as essential fish habitat (EFH) of bluefin tuna and blue marlin, and report on the movement and stock structure of individuals that frequent this marginal sea at some part in their life history. Data from several of sources support the premise that the Gulf serves as EFH of bluefin tuna and blue marlin, and the region appears critical to the sustainability of both species. Observer data and logbook catch records from the U.S. long-line fleet demonstrate that both species frequent the Gulf and occupy the northern section of this basin during presumed spawning periods. Larval distribution data support the assertion that the Gulf represent critical spawning habitat of both species as well as other large pelagic species, which commonly aggregate along "hot spots" of productivity in the northern region. Electronic tagging and otolith chemistry data further document utilization patterns in the Gulf and highlight the unique nature of bluefin tuna and blue marlin populations. For bluefin tuna, residency times are limited and directed movements out of Gulf occur after spawning in a predictable manner. Long-distance movement often occurs after leaving the Gulf and a similar pattern of movement occurs for the eastern stock (spawns in Mediterranean Sea), which intermingle with Gulf-spawned individuals as they migrate into the western and central Atlantic. In contrast, movements of blue marlin out of the Gulf appear less directed with a large fraction of the population remaining in the Gulf from summer spawning periods into the winter. As a result, the Gulf component of blue marlin may have a separate migration pathway from the Atlantic population. The theory of distinct population components or contingents appears to apply to both Atlantic bluefin tuna and blue marlin in the Gulf, and further information on movement and population structure of both species is clearly needed to effectively manage these pelagic voyagers.

GENETIC VARIABILITY OF THE WHALE SHARK (*RHINCODON TYPUS*) IN TWO ISOLATED POPULATIONS: CARIBBEAN (HOLBOX ISLAND) AND GULF OF CALIFORNIA

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The whale shark (*Rhincodon typus*) is epipelagic with a circumtropical distribution. The whale shark has a K-selected life history that makes it vulnerable to exploitation, such as large size, slow growth, late maturation, extended longevity, and probably small populations. It is a highly migratory organism, and sustainable use of this threatened species depends on international collaboration. Our knowledge of its biology, ecology, and behavior is limited and hampers our ability to implement appropriate protection for conservation. In 2000 whale shark was listed as vulnerable on the IUCN Red list and was included on the red list in Mexico in 2001 because of the population decline in the last years which could result in a negative effect on their populations. To properly manage the species, it is

necessary to asses levels of inter- and intra population variation so that management units can be accurately defined. Quantification of inter- and intra-specific sequence variations within the mitochondrial (mtDNA) genome is a powerful tool for examining questions of population genetic structure, gene flow, and migratory movements within and among different populations of sharks. In collaboration with the National Commission of Protected Natural Areas (Área de Protección de Flora y Fauna Yum Balam and Parque Nacional Isla Contoy), a project was undertaken to study the population genetics of the whale shark. A highly variable fragment of the mtDNA control region of the whale shark was amplified and sequenced to characterize the amount of genetic variation within populations in the Gulf of California (n = 65) and Holbox Island in the Caribbean Ocean (n = 58). We found higher levels of variation in the Gulf of California with 23 haplotypes (h = 0.92, π = 0.01) than the Holbox Island with 15 haplotypes (h = 0.78,π= 0.01). AMOVA analysis revealed significant geographic difference among the two ocean basis, indicating that the whale shark populations are structured on a geographic scale.

BEYOND THE SPECIES ID OF THE EARLY STAGES OF TUNAS AND BILLFISH: THE ADVANTAGES OF DNA SEQUENCING

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Early life history stages of tunas and billfish are difficult to identify based on meristic and morphological characters. Advances in molecular genetics techniques based on the polymerase chain reaction (PCR), have over the last decade provided means to identify (ID) fish larvae using minute amounts of tissue preserved in a variety of ways. Here we present data generated to the forensically ID tuna and billfish larvae from the Gulf of Mexico, and tuna larvae from the Gulf of Guinea, based on nucleotide polymorphisms of the mitochondrial DNA (mtDNA) control or d-loop region. While other molecular ID techniques, such as PCR-RFLPs and multiplex PCR assays, are faster and more economical to conduct than sequencing, they do not contain the wealth of information stored in sequence data. We illustrate these added benefits of sequencing with studies of tunas and billfish in the areas of population structure, assessments of historical demography and estimates effective population size, molecular systematics, molecular ecology and evolution, and the assessment of reproductive variance and other behavioral correlates.

STUDIES OF YELLOWFIN TUNA AGGREGATIONS AROUND DEEPWATER PETROLEUM PLATFORMS IN THE NORTHERN GULF OF MEXICO

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Oil and gas production in the northern Gulf of Mexico has expanded into deep waters of the outer continental shelf, where the deepwater petroleum structures (DPSs) act as fish aggregating devices (FADs) for tunas and other species. We initially studied yellowfin tuna (YFT) aggregations around a DPS by tracking acoustic-tagged fish from a research vessel (Edwards and Sulak, 2006) and more recently, around a large spar platform, *Medusa*, 69 km off the Mississippi delta moored in 678 m depth, by attaching automatic receivers to the platform at 9 m depth, and tagging 31YFT with surgically-implanted, coded acoustic transmitter tags in July, 2005. Most fish remained highly associated with the platform, with many present for relatively long, continuous periods without day-scale absences early in the monitoring period; many returning for periods of several days after day-scale absences; some returning more than one time; and several returning after long absences. The pattern of residence was dissimilar to other, disparate patterns reported in comparable studies of YFT at FADs and seamounts, showing that YFT aggregation, residence, movement, and migration patterns are complex and vary greatly from location to location. The patterns observed in this study suggest that DPSs greatly affect YFT presence, distribution, movement, catchability, and possibly population structure in the northern Gulf of Mexico. Because the impact is potentially large, a new study is being planned for 2007, in which all or most of the DPSs in the Mississippi Canyon area will be instrumented, and a large number of YFT (~150) will be tagged and monitored. Additionally, YFT movement to and from a natu-

ral bathymetric feature (Sackett Bank = Midnight Lump), an area of aggregation during winter supporting a large recreational fishery, will be assessed by tagging some fish there and by deploying monitoring instruments during winter 2007–2008.

MOVEMENT PATTERNS AND HABITAT PREFERENCES OF WAHOO, *ACANTHOCYBIUM SOLANDRI*

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The wahoo, *Acanthocybium solandri*, is an offshore marine fish which inhabits tropical, subtropical, and warm temperate waters worldwide. Wahoo are reported to be highly migratory and to visit a wide variety of open ocean habitats, and are economically important over most of their range. Despite this mobility and commercial value, there is very little scientific data concerning the movement patterns or habitat preferences of wahoo. This presentation describes our research project using pop-up satellite tags (PSAT's) to study the movements and habitat preferences of wahoo in the western Atlantic Ocean. A PSAT is a technologically advanced wildlife tag which can monitor the movements of pelagic fishes, independent of potentially biased commercial fishery data. Computer chips on-board each PSAT measure and record water depth, water temperature, and fish position over a pre-determined period of time. At the end of this period, the PSAT's on-board computer initiates a detachment signal and the positively buoyant tag floats to the surface. The stored data is transmitted to a satellite and then to the researcher's computer via electronic mail and the World Wide Web. This presentation describes the protocol used to capture, tag, and release wahoo and presents preliminary data obtained from the first several tags to be successfully deployed.

FROM CAPE COD TO THE GULF OF MEXICO: MOVEMENT AND BEHAVIOR OF OCEAN SUNFISH, *MOLA MOLA*

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During the pilot season of a three-year PSAT tagging project of ocean sunfish, *Mola mola*, in the northwest Atlantic, an ocean sunfish was tagged and released with a pop-up satellite archival tag off of Cape Cod, MA and tracked for 130 days. The fish traveled a distance of approximately 3,000 km to the Gulf of Mexico. Vertical movement of the fish in waters off New England after initial tagging was at depths ≤ 200 m with large amounts of surface time, as was consistent with two other fish tagged in the area. However, as the fish moved southward, its vertical behavior changed to increased time at depth (200-500 m) and no time at the surface. Maximum depth for the fish was 591 meters. The fish spent the majority of time in waters between 10-20°C, experiencing increased temperatures when it entered the Gulf of Mexico. In the project's first field season following the pilot study, 15 fish were tagged with PSAT's in the northwest Atlantic during the months of July and August 2006. The objectives of the study are to: 1) determine the spatial and temporal distribution of *Mola mola* off the northeast coast of the United States; 2) study their movement and migratory patterns; and 3) quantify temperature and depth preferences of *M. mola*. In addition to tagging, the project includes analysis of aerial sightings of *Mola mola* in northeast shelf waters from several databases (1974–present).

MANAGEMENT: STRATEGIES, PROBLEMS AND SOLUTIONS ABSTRACTS

LARGE PELAGIC SPECIES PERMIT HOLDERS IN THE CARIBBEAN SEA AND GULF OF MEXICO: STATISTICS, CHARACTERISTICS, AND DEMOGRAPHIC TRENDS

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Vessel owners who fish recreationally for regulated tunas, sharks, swordfish, and billfish in US federal waters of the Caribbean Sea and the Gulf of Mexico must obtain a Highly Migratory Species (HMS) permit. Vessel owners who fish commercially for regulated tunas in the Caribbean Sea and the Gulf of Mexico must obtain an Atlantic Tunas permit. This paper explores statistical and demographic trends over the past seven years in US vessels permitted to fish for large pelagics in the Caribbean Sea and Gulf of Mexico. Data from permitted vessels with principle ports in the following states/territories were included in this study: Florida, Alabama, Mississippi, Louisiana, Texas, Puerto Rico, and the US Virgin Islands. Historical permit databases were analyzed for the three largest permit categories for large pelagic species: HMS Angling category, HMS Charter/Headboat category, and Atlantic Tunas General category. Trends in the number of permits sold by category, principle port state/territory, and city were investigated. This study also assessed the prevalence of permit category switching over time and evaluated turnover among Caribbean and Gulf of Mexico large pelagics fishing vessels based on persistence in permit databases. Vessel length was also analyzed by permit category and principal port state. Implications of these findings for the management of large pelagic fishes in the Caribbean Sea and Gulf of Mexico are discussed.

SPATIO-TEMPORAL PATTERNS IN THE GULF OF MEXICO PELAGIC LONGLINE FISHERIES

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This poster presents data on the spatio-temporal patterns of effort and catches by United States and Mexican pelagic longline fleets operating in the Gulf of Mexico. These data were collected through the scientific observer programs of each country, beginning in 1992 for the U.S. and in 1993 for Mexico. The combined database was jointly analyzed under the auspices of MexUS-Gulf (the cooperative program between the U.S. National Marine Fisheries Service and the Mexican National Fisheries Institute, INP). The distribution of effort across years and seasons/quarters is examined, along with its relationship to depth contours and to other factors such as seas surface temperature patterns. Likewise, the distribution of catches is studied, scaled by relative catch rate levels. The primary focus is on yellowfin tuna (*Thunnus albacares*) as this is the main target species of these fisheries, but attention is also given to various other species which are caught.

RECREATIONAL CATCH AND RELEASE: RESOURCE ALLOCATION BETWEEN COMMERCIAL AND RECREATIONAL FISHERMEN

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Recreational catch and release is a management option for some species that are treasured for their sporting value. This management option for shared fisheries is not entirely compatible with the management objective of obtaining maximum sustainable yield as envisioned by many management institutions. Released recreational catch can simply be caught and removed from the population by commercial interests thereby increasing their catches while still maintaining the population at the same level. A logistic surplus production model is applied to an arbitrary fish stock to show that if the commercial harvest is not allowed to increase, the stock will grow because of the recreational releases, eventually resulting in higher catch rates for both recreational and commercial fishers. This option has the potential to benefit both user groups.

FILLING THE INFORMATION GAP: THE BILLFISH FOUNDATION'S COOPERATIVE TAGGING PROGRAM

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The Billfish Foundation's (TBF) Cooperative Billfish Tagging Program began in 1990 and to date has compiled data on over 130,000 animals. Tag and recapture efforts occur in the Atlantic, Pacific and Indian Oceans. The program is built upon the volunteer support of anglers, captains and mates and provides the means to generate large tagging data sets in a cost effective fashion. This paper reports on recent program advances; including increased international outreach efforts and a web-based data entry and retrieval system.

STOCK ASSESSMENT AND MANAGEMENT ADVICE FOR THE KING MACKEREL (*SCOMBEROMORUS CAVALLA*) FISHERY OF TRINIDAD AND TOBAGO

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This paper reports on a stock assessment of an assumed 'southern Caribbean' stock of king mackerel, based on length frequency data collected in Trinidad and Tobago mainly in the years 1996 to 1998 (total $n = 2200$), and a second smaller data set from 2004 ($n = 558$). Von Bertalanffy growth rates were first estimated using the combined 1996–98 data set in the FMSP LFDA package. The analysis provided two sets of growth parameters, a 'low L_∞' model (L_∞ = 130cm, associated with a K of 0.35), and a 'medium L_∞' model (L_∞ = 155cm, with a lower K of 0.30), both of which provided equally good fits to the main modes in the data set. Total mortality rates (Z) were estimated for each of the two growth models as 1.26 and 1.70 for the 1996–1998 data set, and as 1.99 and 2.50 for 2004. With estimated natural mortality rates (M) of 0.59 and 0.51 for the low and medium L_∞ growth models respectively, fishing mortality rates, F, were estimated as 0.67 and 1.19 for 1996–1998 and 1.40 and 1.99 for 2004. An 'analytical' or 'per-recruit' model was then fitted using the FMSP 'Yield' software, using a standard Beverton and Holt formulation. Based on a draft objective of "maintaining the sustainability of resources", the $F_{20\%SPR}$ reference point was adopted as an upper limit or threshold fishing mortality rate, that should not be exceeded. The two growth models gave $F_{20\%SPR}$ estimates of 0.80 and 0.66. The 1996–98 fishing rates were thus either 16% below or 80% above the $F_{20\%SPR}$ reference point, depending on which growth model was used. For the higher 2004 estimates of fishing mortality rates, both models suggest that the fishery was operating well above the assumed 'safe' levels of the $F_{20\%SPR}$ reference point (i.e., 85–202% above). Consideration was given to adjustments in fishing effort levels that could be used to reduce F to below the limit reference points. Guidance was also provided on closed seasons and fish size limits that could alternatively be used to maintain spawning stock biomass per recruit above the limit 20% level. Due to the small length frequency sample size available in 2004 and the high level of uncertainty in

the analysis, the study concluded that new length data should be collected urgently to clarify the current position of the fishery. Responsible management will also require improved understanding of the stock distribution, and the harmonization of management measures in each of the states that share this stock.

REMOTELY SENSED RED TIDE FEATURES AND THEIR RELATIONSHIP WITH RECREATIONAL KING MACKEREL CATCH OFF WEST-CENTRAL FLORIDA

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A strong red tide caused by the toxic dinoflagellate *Karenia brevis* was present off of the central West Florida Shelf from January through at least November 2005. A new technique to use solar stimulated phytoplankton fluorescence, from the MODIS Fluorescence Line Height (FLH) data product, was used to remotely sense phytoplankton concentrations in the ocean surface. Algorithms to detect frontal features in satellite-derived FLH, chlorophyll concentration, and turbidity images were used to study the linkages between recreational catch of king mackerel (*Scomberomorus cavalla* or kingfish) and red tides in coastal waters off west-central Florida. The FLH data were used to characterize the spatial distributions of the red tide and its features over the course of 2005. FLH data allowed clear identification of chlorophyll patches as opposed to darker waters related to river discharge along the coast. A Geographical Information System (GIS) tool was used to examine spatial relationships between catch data and ocean fronts, bathymetric features, the presence of baitfish , and the stability of fronts over the three-day period leading up to the tournaments. There was a strong correlation between the presence of baitfish and kingfish catch rates, and catch rates decreased in more turbid waters identified in ocean color imagery. Concurrent with the 2005 red tide event a significant decrease in kingfish catch was found in the fall of 2005 (208 kingfish) compared to spring 2004 (444) and 2005 (538), and fall 2004 (818). Percentages of fishing locations where baitfish were observed also decreased in the fall 2005 (38%) compared to spring 2004 (54%) and 2005 (51%), and fall 2004 (54%). Quantifying the relationships between kingfish catch and its forage is an essential step in forming ecosystem-based management strategies. Satellite data is important in defining ecosystem-scale connections.

DESCRIPTION AND CONSERVATION IMPLICATIONS OF MARTINIQUE FAD FISHERIES

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Current use of moored Fish Aggregating Devices (FAD) presents the twofold drawback of encouraging the catching of juvenile fish and of blue marlin (*Makaira nigricans*) for which the International Commission for the Conservation of Atlantic Tunas (ICCAT) recommends a reduction in catches. To attempt to find solutions to these problems, a description of FAD fishing in Martinique was carried out via surveys during 2004 and 2005 A comparison of the catches was performed according to the location of the FAD and the time of fishing. The variation in the fishing compared to assessments made between 1998 and 2003 is also described. Analysing these data shows that over a few years yellowfin tuna (*Thunnus albacares*) has become the main species caught around FAD (50%). This species, along with blue marlin, accounts for 85% of landings. However, the number of blackfin tuna (*Thunnus atlanticus*) caught does not seem to have progressed, whereas this species makes up the majority of the biomass aggregating around these devices. Given the current state of knowledge about this species, it would seem that FAD near the coast are necessary in order to favour the fishing of adult blackfin tuna, whereas for yellowfin tuna, the best yields are obtained with devices further from the coast.

FISHING EFFORT AND PRODUCTION OF FISHING ASSOCIATED WITH MOORED FADS IN MARTINIQUE ESTIMATION BY PHONE SURVEYS

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In order to estimate at an island scale the capture made by the emergent FADs fishing, two types of phone surveys have been realised. First, weekly surveys have been made during two years from voluntary FADs fishermen, on two different areas of Martinique. From these surveys, the numerical and ponderal capture per species has been detailed. The seasonality of the landings is described and shows the periods where low yield can force fishermen to abandon the FADs and go back to exploit the insular shelf resources. Length frequencies of captures, in particular of blue marlin (*Makaira nigricans*) are established with the estimation of individual weight declared by professional fishermen. The extrapolation to the whole fishery of Martinique has been made with a random sample of 10 percent of the fishing fleet. This survey also gives the proportion of boat fishing around FADs.

MANAGEMENT OF MOORED FISHING AGGREGATING DEVICE (FADS) IN THE LESSER ANTILLES: A BIO-ECONOMIC APPROACH

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The objective of this paper is to analyse the biological and economic implications of different management and funding regimes (private, public, collective) of the moored fishing aggregating devices (FADs). To consider this issue, a simple model of the commercial exploitation of a pelagic resource in a given area is developed to illustrate the potential effects of fishermen congestion around FADs and the biological interactions between the devices. Sensitivity analysis on the control variables of the model—the number of fishing unit and the number of FADs in the fishery—provide results on the level of profit and rent for the individual fisherman and for the total fleet. It illustrates the risk of rent dissipation in the case of mismanagement of the FADs as well as overcapacity in the fleet. Empirical evidence from a selection of fisheries in Martinique and Guadeloupe is used to discuss the assumptions and the results of the model.

CHALLENGES FOR THE MANAGEMENT OF AN EXPANDING SHARK FISHERY, WITH HIGH UNCERTAINTIES TOWARDS NEW CONSERVATION POLICIES IN THE SAN ANDRES, PROVIDENCIA AND SANTA CATALINA ARCHIPELAGO, COLOMBIA

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For over 20 years the Archipelago has held a strong fishing pressure at an industrial level centered principally on the extraction of the spiny lobster, queen conch and demersal fishes (snappers and groupers). However, in the last 5 years a new fishery has emerged targeting shark species, but unfortunately it has not been monitored. This study documents for the first time this shark fishery and established that 13 species of these elasmobranchs were captured; the majority included in the red list of the IUCN under different risk categories. Only one species, *Carcharhinus perezi,* makes up the majority of the fishery, representing nearly 68% of all sharks captured. Thus, *C. perezi* is vulnerable to overfishing, a condition that is accentuated with the high proportion of juveniles that are caught. The shark fleet operates over different areas in the north of the Archipelago, with a large part of the fishing effort inside a recently implemented system of marine protected areas of multiple used. Shark fishing occurs over zones where industrial fishing is not actually permitted, frequently affecting the coral habitat because of the use of

destructive fishing gear. Also, there exists a high level of uncertainty about the population ecology of the sharks caught and the effects that fishing of these top predators has on the trophic interactions in the ecosystem. Under these circumstances, local fisheries managers face true challenges in order to obtain an adequate management of this expanding fishery.

IMPACT OF ANNUAL AGGREGATIONS OF WHALE SHARK (*RHINCODON TYPUS*) ON THE NORTH AND NORTHEAST COMMUNITIES OF THE YUCATAN PENINSULA

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In just 3 years the lifestyle of communities on the north and northeast coast of the Yucatan Peninsula, Mexico has changed dramatically due to the occurrence of whale sharks in the area. What used to be a fish of no economic importance has become a factor of additional income to the populations of Holbox, Isla Mujeres and Cancun. This species has become the center of tourist activity in the Holbox area because the community is located at the closest site for the observation and swimming near the whale sharks. Data and statistics are presented to understand this phenomena which shows changes that have taken place within the communities and joint actions taken by both inhabitants of the community and authorities. Also presented are the results of a research project designed to learn more of the biology and the population dynamics of whale sharks as well as to evaluate the best strategies for the protection and conservation of the species. The results show that benefits could be achieved with compliance to the measures and regulations which have been designed. Although whale sharks are a transboundary species and its conservation depends on the efforts of many countries, the results presented here show the actions that could be achieved locally in a global effort for the conservation of the species.